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WINTER EROSION IN FOUR RESIDUE MANAGEMENT SYSTEMS: PRELIMINARY REPORT

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INTRODUCTION

About 86 percent of the erosion in the dryland cropping areas of the Pacific Northwest occurs during low intensity rainfall on frozen soil, snow melt on frozen soil, or rain and snowmelt on frozen soil (Zuzel et al. 1982). Soil loss is greatest from the approximately 4.5 million acres (Smiley 1991, McCool et al. 1993) that are planted to winter wheat following summer fallow. Soil loss from the more erodible of these fields will range from 10 to 150 t yr^{-1}.

Although rills produce an estimated 90 percent of the eroded material (Zuzel et al. 1993), erosion begins as sheet flow, unconcentrated flow across the soil surface, before flow concentrates to form rills. A number of factors reduce or nearly eliminate sheet erosion. In fallowed fields, a roughly plowed soil surface produces many detention dams to store water from small impermeable runoff areas and provides open pathways to subsurface soil that is not frozen. Alternatively, residue stubble can be left standing to provide residue cover and intact root structure. In fall planted winter wheat, cover provided by either residue or green crops reduces the soil erosion by raindrop splash and sheet flow. Zuzel and Pikul (1993) suggest that less than 25 percent cover is ineffective for erosion control.

Obtaining 30 percent cover with moldboard plowing and two to three tillage operations is not always possible. Residue must be managed not only to provide erosion control, but to overcome equipment limitations, assure disease and weed control, and improve seedbed preparation. Residue can be in excess of 15,000 lb ac^{-1} in fields with 90 to 150 bu ac^{-1} wheat yield. These residue levels are generally incorporated completely with a moldboard plow or burned, which leaves little or no cover residue. Chisel plowing in these levels of residue often results in a combination of weed, disease, equipment, and seedbed preparation problems.

We developed a mow-plow residue management system to solve heavy residue, weed, and seedbed preparation problems. We mounted a harvester-header on the front of a tractor to cut and sidecast residue onto adjacent moldboard plowed surface. The moldboard plow was pulled with the same tractor. Thus, each circuit of the field placed residue on the previous moldboard pass. Some residue was incorporated into soil by subsequent rodweeding and seed drill disturbance. Header height can be adjusted to vary the amount of residue turned under by the moldboard plow. Research conducted to date (Wilkins, unpublished data) suggests this system does not increase soil-borne disease problems and provides effective weed control.

We conducted this research to determine the soil and water conservation effectiveness of the mow-plow system relative to moldboard and chisel plowing.

METHODS

Duff (3D) Ranch and Reeder Farms provided plot sites for this research

approximately 10 miles north of Pendleton and within agronomic zone 3 (Douglas et al. 1990). The analysis of data reported here is preliminary.

We simulated rainfall using a newly developed rainfall simulator to mimic rainfall on frozen soil (Williams et al. 1996). Rainfall was simulated during warming periods following periods sufficiently cold to freeze the soil 6 - 18 in. deep in January and February of 1996 and 1997. Rainfall intensity was 0.32 in. hr^{-1} and maintained for 90 minutes after runoff began. We simultaneously simulated rainfall onto four residue tillage treatments in individual plots. The treatments were:

(1.) chisel plow,
(2.) moldboard plow,
(3.) mow-plow low residue (l), and
(4.) mow-plow high residue (h).

Residue levels after primary tillage were 1,880 lb. ac^{-1} for the mow-plow (l) at and 5,440 lb. ac^{-1} for the mow-plow (h) treatments. Residue rates represent the amount of residue needed for 30 percent cover after secondary tillage, fertilizing, and seeding and all the residue from fallowed stubble, respectively.

We measured residue and plant cover, depth of frozen soil, time to ponding, time to runoff, and runoff amounts every 10 minutes for 90 minutes after runoff began. We collected runoff in 1 liter bottles in 10 minute intervals and weighed, dried, and reweighed the bottles to determine both runoff rate and soil loss. We calculated erosion rates by regressing accumulated ten minute increment soil loss against time.

RESULTS

Runoff rates did not differ significantly between treatments. Small rills developed in each of the treatments, but were not quantified. Erosion rates differed between dates and treatments. For example, soil erosion averaged across treatments was 1,550 lb. ac^{-1} and 470 lb. ac^{-1} with no snow or 1 inch snow, respectively. A general pattern emerges the average of two days erosion rates onto bare soil (Figures 1 & 2). The most effective erosion control treatment was the chisel plow, followed closely by the mow-plow (h). The mow-plow (l) treatment was not distinguishable from either high residue treatments or the moldboard plow treatment. The erosion rate in the moldboard plow treatment was significantly greater than either of the high residue treatments at the end of one hour.

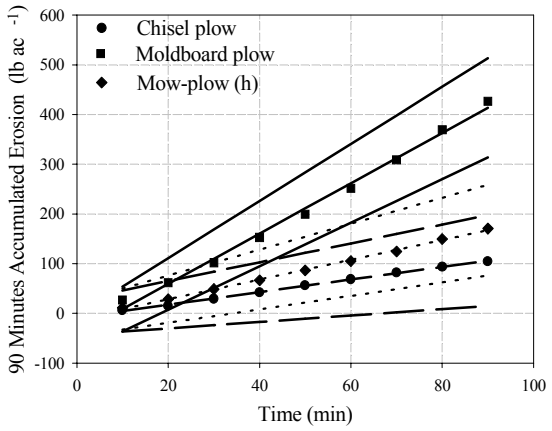

Fig. 1. Relationship of moldboard plow, mow-plow (h), and chisel plow erosion rates from eroded material accumulated for 90 minutes after runoff began. Means of two simulations and confidence intervals (95 percent) shown for fitted relationship.

DISCUSSION

The mow-plow system provides an alternative to chisel plowing for leaving surface residue cover. It also provides the opportunity to examine, in the following

discussion, the differences in erosion protection provided by anchored residue, crown, and root material versus residue left on the surface. Moldboard and chisel plowing represent the two extremes of residue cover for cover and erosion (Fig. 3).

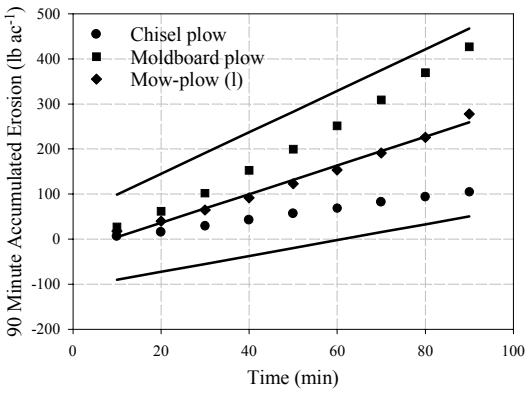

Fig. 2. Relationship of moldboard plow, mow-plow (l), and chisel plow erosion rates from eroded material accumulated for 90 minutes after runoff began. Means of two simulations and confidence intervals (95 percent) shown for fitted relationship of mow-plow (l) demonstrating variability of low residue application.

Mow-plow cover erosion values fall between these extremes. High variability in the mow-plow (l) treatment suggests that sparse residue cover alone might not provide adequate erosion protection, because of either insufficient surface residue or lack of residue incorporation. In the mow-plow (h), nearly half of the applied residue was incorporated in the soil surface by subsequent tillage. Erosion in the mow-plow (h) treatment was 40 percent of that for the moldboard treatment, but nearly double that of the chisel plow.

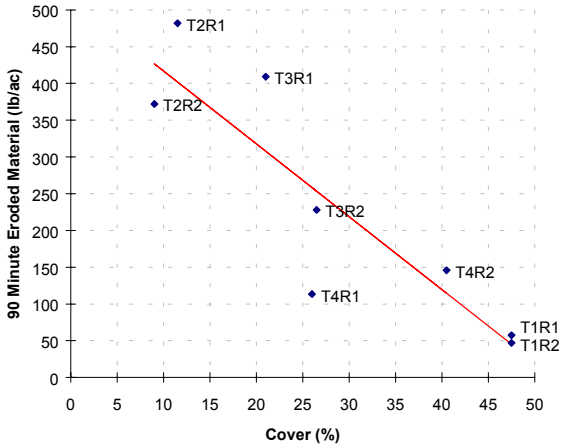

Fig. 3. Total eroded material from two runs versus residue cover. Treatment designations are: Chisel plow (T1), moldboard plow (T2), mow-plow (l) (T3), and mow-plow (h) (T4).

CONCLUSION

The mow-plow system did not influence infiltration rates. A light application of residue using the mow-plow system had no apparent influence on soil erodibility. A heavy application of residue significantly lowered the rate of erosion relative to the moldboard plowing. We demonstrated the importance of incorporated residue by comparison of the two mow-plow treatments with the chisel plow. Considering the relative erosion responses by the mow-plow (l) and (h) treatments, incorporating residue might be as important as surface cover alone. The presence of the root and crown structure in the chisel plow treatment appears to contribute additional protection against soil erosion. This research is preliminary in that it dealt with the onset of a thaw event producing only raindrop and sheet erosion. Additional research is required to determine effectiveness of the

mow-plow system through an entire thawing event with rill development.

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